NON-TECHNICAL SUMMARY

ENVIRONMENTAL SURVEY OF IDENTIFIED SAND RESOURCE AREAS OFFSHORE ALABAMA

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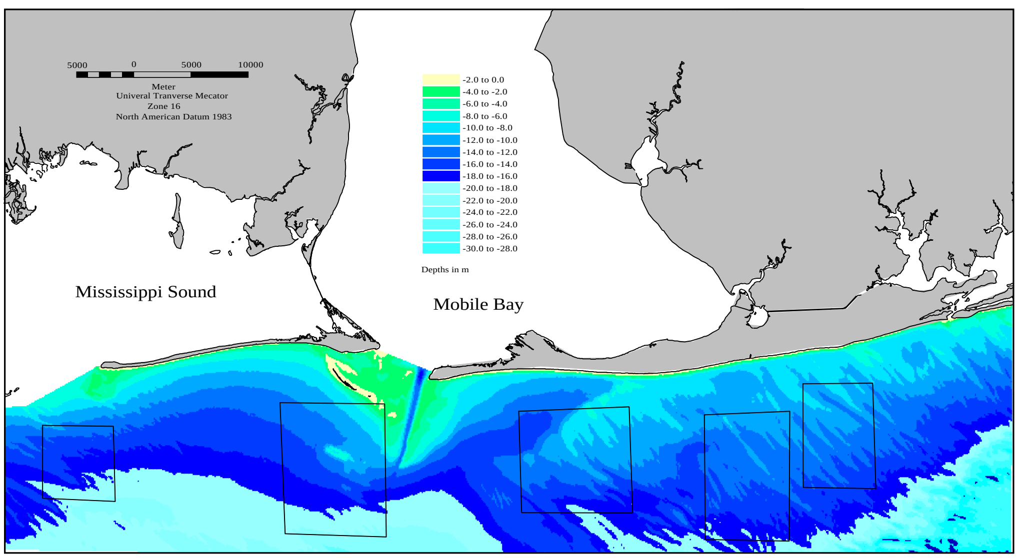

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In recent years, there has been increasing interest in sand and gravel mining on the Outer Continental Shelf (OCS). Currently, the U.S. Department of the Interior, Minerals Management Service (MMS), International Activities and Marine Minerals Division (INTERMAR) is overseeing at least eight Federal-State task forces, several cooperative agreements, and at least four environmental surveys to ensure substantive government and public involvement and attention to regional, State, and local concerns regarding leasing, engineering, economic, and environmental aspects of sand and gravel mining. Under the Outer Continental Shelf Lands Act (OCSLA), the MMS is required to conduct environmental studies to obtain information useful for decisions related to negotiated agreements and lease activities. As such, the MMS pursues its responsibilities for management of offshore sand and gravel mining by:

- protecting ocean and coastal environments by ensuring that all OCS sand and gravel mining activities are environmentally acceptable;
- ensuring that OCS sand and gravel activities are compatible with other uses of the ocean;
- involving coastal States in all aspects of sand and gravel mining activities; and
- evaluating the potential of the OCS as a domestic source for sand and gravel resources.

To this end, the MMS initiated four environmental studies along the Atlantic and Gulf coasts in 1997 to provide information for programmatic marine mining decisions at MMS Headquarters and OCS Regional Offices. The report discussed in this summary presents results of the first of four environmental studies administered through the MMS INTERMAR. The report was prepared under MMS Contract No. 14-35-01-97-CT-30840 by Applied Coastal Research and Engineering, Inc. (Applied Coastal) in cooperation with Continental Shelf Associates, Inc. (CSA), Aubrey Consulting, Inc. (ACI), and Barry A. Vittor & Associates, Inc. (BVA). ACI served as the prime contractor.

BACKGROUND

The inshore portion of the Alabama continental shelf, seaward of the Federal-State OCS boundary and within the Exclusive Economic Zone (EEZ), encompasses the project study area (Figure 1). The seaward limit of the study area is defined by the 30^{o}N latitude line. The continental shelf within the study area is relatively broad and featureless west of the Mobile Bay entrance; however, the Alabama shelf east of the entrance channel contains many northwest-southeast trending shoreface sand ridges, as well as other shoals.

Five potential sand resource areas were defined within the study area through a Federal-State cooperative agreement between MMS INTERMAR and the Geological Survey of Alabama (GSA). For the present study, a borrow site within each of Sand Resource Areas 1 through 4 were defined to evaluate potential impacts of sand mining for beach replenishment. Sand Resource Area 5 was not included in the analysis because it is away from beach areas of greatest replenishment need, and the sediment was least compatible with native beach sand. This report summarizes the results of physical and biological studies aimed at understanding the potential ecological impacts of sand mining at these sites to promote environmentally sound development of sand resources.

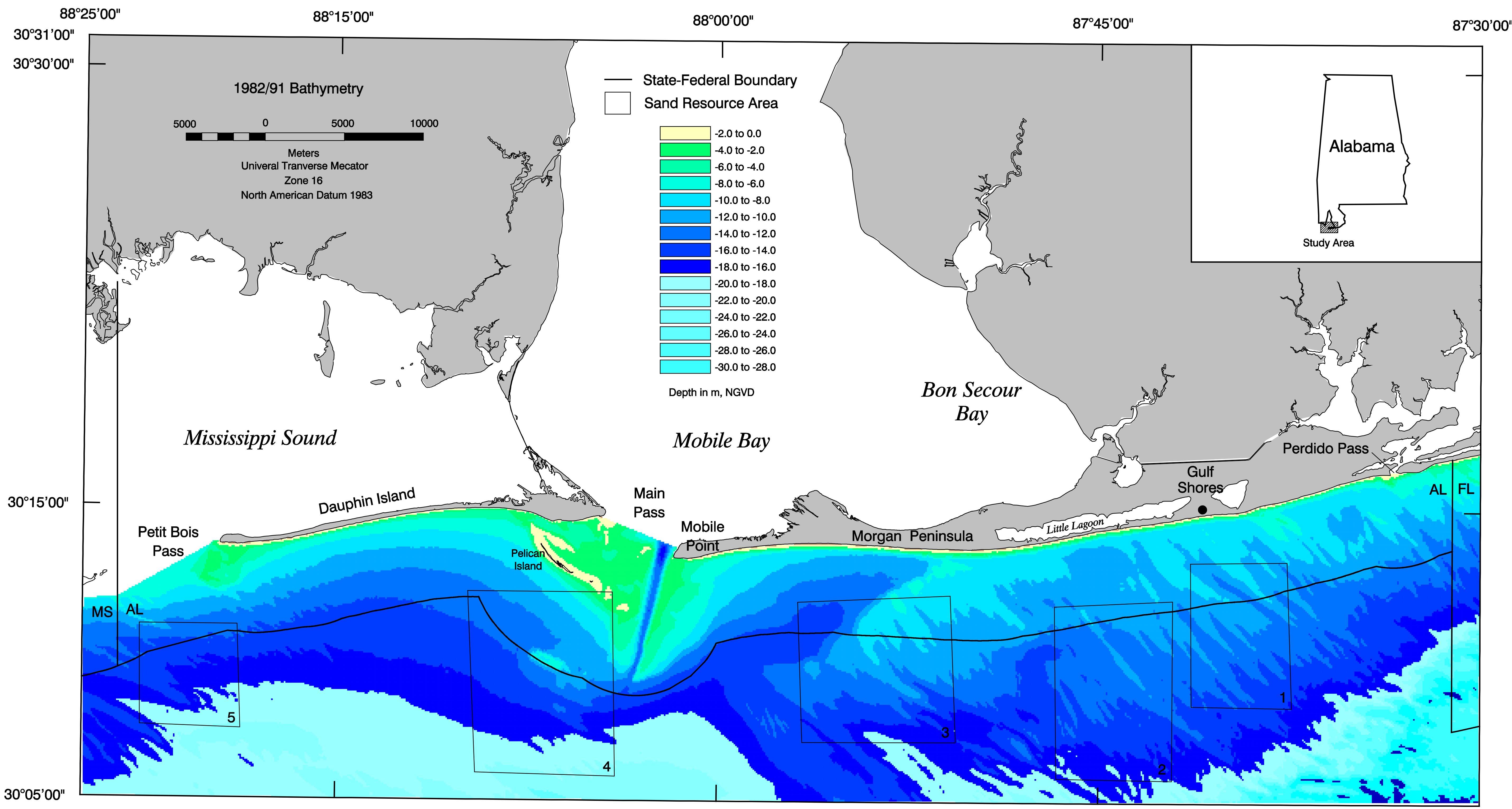

Figure 1. Location of Alabama study area and potential sand resource sites.

PURPOSE

The purpose of this study was to assist the MMS in assessing the potential impacts of dredging sand from the OCS offshore Alabama for beach replenishment. The primary environmental concerns focused on physical and biological considerations. To this end, seven study objectives were identified:

- Compile and analyze existing oceanographic literature and data sets to develop an understanding of existing environmental conditions offshore Alabama and the ramifications of dredging operations at selected sand borrow sites;
- Design and conduct physical and biological field data collection efforts to supplement existing resources;
- Analyze the physical and biological field data sets to address basic environmental concerns regarding potential sand dredging operations;
- Use physical processes field data sets and wave climate simulations to predict wave transformation under natural conditions and in the presence of proposed dredging activities;
- Determine existing coastal and nearshore sediment transport patterns using historical data sets, and predict future changes resulting from proposed sand dredging operations;
- Evaluate the potential cumulative environmental effects of multiple dredging scenarios; and
- Develop a document summarizing the information generated to assist with decisions concerning preparation of an Environmental Assessment/Impact Statement to support a negotiated agreement.

It is expected that information presented in the Final Report will enable the MMS to identify ways in which dredging operations can be conducted to minimize or prevent long-term adverse impacts to the marine environment.

SIGNIFICANT CONCLUSIONS

The following discussion provides a summary of results and conclusions regarding the potential environmental effects of sand mining on the OCS for replenishing sand to eroding beaches. Because benthic and pelagic biological characteristics are in part determined by spatially varying physical processes throughout the study area, physical processes analyses are summarized first.

Wave Transformation Modeling

A primary component of any physical environmental effects analysis related to sand mining from the OCS should include computer modeling of wave movement from offshore to the coast. Potentially rapid and significant changes in seafloor shape due to sand dredging from the OCS may have substantial impact on wave patterns across the continental shelf and at the shoreline. In turn, sediment movement on the seafloor and at the beach may be altered so as to adversely impact erosion problems being mitigated. As such, substantial effort was spent understanding existing wave patterns relative to those resulting from potential sand dredging activities.

A spectral wave model was selected to simulate changing wave patterns because of its ability to propagate individual components of a wave energy distribution (a spectrum) simultaneously across the continental shelf. By simulating several wave components simultaneously, a spectral wave model represents nature more closely. From previously collected data, prevalent seasonal conditions were used to generate representative seasonal wave climates. Seasonal wave conditions were selected to represent the differences in spectral wave approach and to investigate long-term average trends in wave and sediment transport patterns. In addition, a storm event (50-yr storm) was developed to investigate potential impacts during high energy conditions.

Wave modeling results indicate that minor changes will occur to wave fields under typical seasonal waves and sand extraction scenarios representing multiple beach nourishment events. Under existing seafloor conditions seaward of Dauphin Island, wave heights are relatively consistent along the shoreline while the eastern end of the island is protected from significant wave energy by Pelican Island and subaqueous shoals associated with the ebb delta. Several areas of wave energy focusing were identified from the Dauphin Island simulations, including those associated with the Mobile Outer Mound disposal site, which concentrates wave energy near Pelican Island during most seasons. Areas of wave energy concentration along Morgan Peninsula are primarily caused by southwest-oriented shoals on the continental shelf. For the 50-yr storm simulation, wave patterns are similar to normal seasonal results. An increase in wave height is significant in many areas where wave energy concentration occurs. For example, the Mobile Outer Mound disposal site concentrates 4.0- to 4.5-m storm wave heights on Pelican Island.

Similar wave modeling results were illustrated for post-dredging simulations. At Dauphin Island, maximum wave height differences for seasonal simulations were as high as 0.2 m. These maximum changes dissipate relatively rapidly as waves break and advance towards the coast. At Morgan Peninsula, maximum wave height differences were slightly larger due to borrow site sizes and orientations, as well as their proximity to the shoreline. However, wave energy is dissipated as waves propagate toward the shoreline, and increases in wave height of 0.1 m or less are observed at the potential impact areas along the coast. Overall, the physical environmental impact caused by offshore sand extraction during seasonal simulations is minimal.

During storm wave conditions, wave heights are modified between 1.5 and 2.0 m, suggesting potentially significant changes. However, for all sand resource sites, a significant amount of storm wave energy dissipates before waves reach the coast. In addition, under storm conditions, wave heights are substantially larger relative to normal wave conditions, regardless of modifications caused by the sand dredging. Therefore, a maximum change may not significantly increase nearshore erosion above existing conditions during storms.

Circulation and Sediment Transport Dynamics

Current measurements and analyses and wave modeling provided baseline information on coastal processes impacting beach environments under existing conditions and with respect to proposed sand mining activities for beach nourishment. Ultimately, the most important data set for understanding physical processes impacts from offshore sand extraction is changes in sediment transport dynamics resulting from potential sand extraction scenarios relative to existing conditions.

Three independent sediment transport analyses were completed to evaluate impacts due to offshore sand dredging. First, historical sediment transport trends were quantified to document regional, long-term sediment movement throughout the study area using historical bathymetry data sets. Second, sediment transport patterns at proposed offshore borrow sites were evaluated using wave modeling results and current measurements. Third, nearshore currents and sediment transport were modeled using wave modeling output to document potential impacts to beach erosion and accretion. All three methods were compared for evaluating consistency of measurements relative to predictions, and potential impacts were identified.

Historical Sediment Transport Patterns

Regional geomorphic changes between 1917/20 and 1982/91 were documented for assessing long-term, coastal sediment transport dynamics. Although these data do not provide information on the potential impacts of sand dredging from proposed borrow sites, they do provide a means of calibrating predictive sediment transport models relative to infilling rates at borrow sites and longshore sand transport.

A comparison of erosion and deposition volumes at proposed borrow sites provided a method for quantifying sediment transport rates (or borrow site infilling rates). For borrow sites in Sand Resource Areas 1, 2, and 3, infilling rates ranged from about 9,000 to 34,000 m^3/yr. This compared well with sediment transport predictions made near borrow sites using wave model output and currents measurements (13,000 to 43,000 m^3/yr). For Sand Resource Area 4, net deposition at a rate of about 65,000 m^3/yr recorded the influence of sediment input from Mobile Bay and local transport processes.

The longshore sand transport rate for Morgan Peninsula was determined by comparing cells of erosion and accretion in the littoral zone between Perdido Pass and Main Pass (Mobile Bay entrance) in a sediment budget formulation. The transport rate for that portion of the study area was determined to be approximately 106,000 m^3/yr to the west. Net transport rates determined via sediment transport modeling ranged from about 50,000 to 150,000 m^3/yr. These rates compare well and provide a measured level of confidence in wave and sediment transport modeling predictions relative to impacts associated with dredging from proposed borrow sites.

Sediment Transport at Potential Borrow Sites

In addition to predicted modifications to waves, potential sand dredging at offshore borrow sites results in minor changes to sediment transport in and around the sites. Modification to bathymetry caused by sand dredging influences local hydrodynamic and sediment transport processes, but areas adjacent to the borrow site do not experience dramatic changes in wave and transport characteristics.

Initially, sediment transport at borrow sites will experience mild changes after sand dredging activities. After several years of seasonal and storm activity, sediment will be deposited at the borrow sites, eventually re-establishing pre-dredging conditions. Given the water depths at the proposed borrow sites, it is expected that minimal impacts will occur during sediment infilling of the borrow site. The pre- and post-dredging differences will be reduced as sediment infills the borrow site, and wave and resulting sediment transport will steadily return to pre-dredging conditions.

Sediment that replaces the dredged material will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. Borrow sites at Sand Resource Areas 1, 2, and 3 are expected to fill with the same material that was excavated. The sediment type in this region is consistent, high-quality, and compatible for beach nourishment. The potential borrow site at Sand Resource Area 4, however, will likely be filled with fine sediment (i.e., fine sand to clay) exiting Mobile Bay by natural processes or human activities (maintenance channel dredging and disposal). Because the potential transport rate plus sediment flux from Mobile Bay is substantially greater than shelf transport rates alone, the borrow site in Sand Resource Area 4 will fill faster than other borrow sites, limiting the likelihood for multiple dredging events from the same area.

Nearshore Sediment Transport Modeling

The potential effects of offshore sand dredging on nearshore sediment transport are of interest because dredged holes can intensify wave heights at the shoreline and create zones of erosion. Therefore, numerical techniques were developed to use nearshore wave modeling results to evaluate beach erosion and accretion.

Sand dredging in Resource Areas 1, 2, and 3 potentially causes a slight change in sand transport along the beach. Due to naturally higher sand transport rates at the eastern end of coastal Alabama, the magnitude of impacts associated with Sand Resource Areas 1 and 2 appear to be higher than those associated with Sand Resource Area 3. For all three sand resource sites, the maximum variation in annual transport rate along the beach landward of the site is approximately 8 to 10% of the existing value. However, the increase or decrease in longshore sand transport rates associated with each potential resource area amounts to approximately 1 to 2% of the longshore sand movement distributed over a 10 km stretch of shoreline.

The potential impacts of dredging Sand Resource Area 4 on beach sand transport rates are insignificant in relation to Sand Resource Areas 1, 2, and 3. Average annual conditions indicate a relatively high percentage change in transport rates along the eastern portion of Dauphin Island; however, the existing alongshore transport is almost non-existent at this location. The net effect of dredging Sand Resource Area 4 would direct a greater percentage of beach sand transport to the east, with a maximum increase of approximately 8,000 m^3/yr.

Overall, the potential impacts of offshore sand dredging throughout coastal Alabama appear to be minimal relative to offshore and beach sand transport patterns. However, for specific project requirements, additional data should be collected to determine the nature and extent of potential impacts.

Benthic Environment

Results of the biological field surveys in the five sand resource areas agreed well with previous descriptions of bottom-dwelling organisms residing in shallow waters off the Alabama coast. Seafloor communities surveyed in the five sand resource areas consisted of members of the major invertebrate (for example, worms, crabs, and clams) and vertebrate (for example, fishes associated with the seafloor) groups that are commonly found in the study region. Seasonality was apparent from the biological field surveys. The abundance of organisms living in the seafloor was substantially higher during the May survey than was observed in December. Potential effects to bottom-dwelling organisms from dredging will result from sediment removal, suspension/dispersion, and deposition. Potential effects are expected to be short-term and localized. Seasonality and recruitment patterns indicate that removal of sand between late fall and early spring would result in less stress on benthic populations. Early-stage succession will begin within days of sand removal through settlement of young recruits, primarily worms and clams.

Recolonization of Areas 1, 2, and 3 east of Mobile Bay should occur in a timely manner and without persistence of transitional assemblages. Infaunal assemblages that typically inhabit the eastern portion of the study area should become reestablished within 2 years. Area 4 infaunal assemblages can be expected to recover more quickly than those in the eastern areas. Because of the physical environmental characteristics of Area 4, especially outflow of fresh water and fine sediment (silts and organics) from Mobile Bay, existing assemblages are comprised of species that colonize disturbed habitats. Infaunal assemblages that inhabit the western study areas would therefore become reestablished relatively rapidly, probably within 12 to 18 months. Given that the expected beach replenishment interval is on the order of 10 years, and that the expected recovery time of the affected benthic community after sand removal is anticipated to be much less than that, the potential for significant cumulative benthic impacts is remote.

Pelagic Environment

Based on existing information, potential effects from offshore dredging could occur to migrating fish populations. Dredging effects on most zooplankton (microscopic aquatic animals) from entrainment and turbidity should be minimal due to the high variability of populations in space and time. If Area 4 is used as a sand source, summer and fall months could be considered to avoid dredging when shrimp and blue crab larvae are most prevalent, but only if additional data become available to determine the extent of impacts and justify the restriction. Dredging is unlikely to significantly affect squid populations in the vicinity of the sand resource areas. Although entrainment, attraction, and turbidity could occur from dredging, quantitative data are lacking to support the use of an environmental window for pelagic fishes.

The main potential effect of dredging on sea turtles is physical injury or death caused by the suction and/or cutting action of the dredge head. No significant effects on turtles are expected from turbidity, low oxygen levels, or noise. Loggerheads are expected to be the most abundant turtle in the project area. Increased numbers of loggerhead turtles may be expected during the nesting season, which extends from 1 May through 30 November. A schedule that avoids the loggerhead nesting season also would avoid potential impacts to occasional nesting green and leatherback turtles. Hawksbill and Kemp's Ridley turtles do not nest anywhere near the project area. It is not known whether sea turtles are likely to be resting in bottom sediments of the project area during winter. Consequently, there is insufficient information to determine whether seasonal restrictions on dredging during winter months would be appropriate.

The two marine mammals most likely to be found in and near the project area are the Atlantic spotted dolphin and the bottlenose dolphin. There is no strong seasonal pattern in abundance for either species that would provide an appropriate basis for seasonal restrictions on the project. In addition, the likelihood of significant impact from physical injury, turbidity, or noise is low even if these animals are present.

OVERALL CONCLUSIONS

Minimal physical environmental impacts due to potential sand dredging operations have been identified through wave and sediment transport simulations. Under normal wave conditions, the maximum change in sand transport dynamics is about 5% of existing conditions. Because wave and sediment transport predictions are only reliable to within about 25%, predicted changes are not deemed significant. Although changes during storm conditions illustrate greater variation, the ability of models to predict storm wave transformation and resultant sediment transport is less certain. Because minimal impacts were documented to wave and sediment transport dynamics, additional data may be required for a specific sand dredging scenario to determine the extent of impacts.

The data collected, analyses performed, and simulations conducted for this study indicate that proposed sand dredging at sites evaluated on the OCS should have minimal environmental impact on water and sediment dynamics and biological communities. Short-term impacts to benthic communities are expected due to the physical removal of borrow material, but the potential for significant long-term and additive benthic impacts is remote. Additionally, no cumulative effects to any of the pelagic groups are expected from potential sand dredging operations.

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